Suggested southern pine tree-grading systems for veneer

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Abstract

Increasing substitution of oriented strandboard (OSB) for pine plywood in sheathing applications will force southern pine plywood mills to produce more specialty products requiring a larger proportion of grade B and better veneer. If an effective system for grading southern pine trees for veneer can be devised and put into use, mill operators will be able to procure trees that yield larger proportions of high-grade veneer and to pay appropriate premiums for such trees. Tree-defect and veneer grade-yield data collected in the 1970s were used to develop and evaluate five experimental tree-grading systems. It was found that tree grades based on size and number of knots and branches correlate better with veneer grade yields than do grades based on number of clear faces. Grading the first three blocks in a tree rather than the first two increases the ability to select trees that yield a high proportion of grade B and better veneer. When the comparison is between no grading and grading based on size and number of branches in the first three blocks, the latter increases the ability to predict grade A veneer yield by 25 percent, grade B by 27 percent, grade C by 7 percent, and grade D by 10 percent (for grade 1 trees).

Projected changes in the sheathing market resulting from increased use of oriented strandboard (OSB) will force southern pine plywood mills to produce more specialty products requiring higher grade veneer. Thus, veneer mills will need to purchase pine trees that yield a high proportion of grade B and better veneer. Projected changes in the southern pine timber resource will also have an increasing impact on wood going to pine plywood mills. As older natural pines are harvested and more plantations reach rotation age, yields of grade B and better veneer will decrease. There are southern pine tree grades for yard and structural lumber[1] but no tree grades are available for southern pine veneer. A southern pine tree-grading system for veneer is needed to assist timber owners in selling trees and veneer mill operators in procuring trees for veneer.

The objective of this study was to evaluate experimental southern pine tree-grading systems for estimating yield by grade of veneer. This paper evaluates five tree-grading systems that were developed based on tree-defect and veneer-yield data for 189 southern pine trees. Questions this study addressed include:

1. How many veneer blocks per tree do we have to grade to estimate tree veneer grade yield accurately?
2. What types and sizes of defect indicators should be included in the grading system?
3. Can existing tree lumber grades be used to estimate veneer grade yields accurately?
4. How much improvement in tree veneer appraisal is obtained by using a grading system rather than one based on tree diameter at breast height (DBH) and veneer merchantable height?

Procedure

The USDA Forest Service, Southeastern Forest Experiment Station, Utilization of Southern Timber Research Work Unit collected veneer yield data for 115 loblolly and 74 slash pine sample trees harvested at five locations and processed at three mills in the 1970s.[2,3] These data, in addition to DBH and merchantable height, included the location, type, and size of each visible surface defect on each of a tree's 8.6-foot

[1] Schroeder, J.G., R.A. Campbell, and R.C. Rodenback. 1968. Southern pine tree grades for yard and structural lumber. Res. Pap. SE-39. USDA Forest Serv., Asheville, N.C. 15 pp.

[2] Phillips, D.R., J.G. Schroeder, and A. Clark III. 1979. Predicting veneer grade yields for loblolly and slash pine trees. Forest Prod. J. 29(12):41-47.

[3] Phillips, D.R., J.G. Schroeder, and A. Clark III. 1980. Reduce pine veneer losses by selecting blocks properly. Forest Industries, April. pp. 40-42.

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TABLE 1. — *Average dry untrimmed veneer volume and proportion in grade by DBH classes for loblolly and slash pine trees combined.*

DBH class	Sample trees	Merchantable height	Tree volume	Veneer yield		Veneer by grade A	B	A&B	C	D	Veneer recovery ratio[b]	Veneer recovery factor[c]
(in.)	(no.)	(ft.)	--- (ft.^{3}) ---		(ft.^{2})[a]	-----	-----	(%)	-----	-----	-----	(ft.^{2}, ft.^{3})
10	16	23	9.0	2.8	89.6	2	16	18	64	18	31.1	9.9
12	32	38	18.4	7.4	236.8	2	16	18	60	22	40.2	12.9
14	34	53	32.3	15.8	505.0	3	12	15	53	32	48.9	15.6
16	30	59	44.4	23.5	751.9	4	12	16	42	41	52.9	16.9
18	36	59	56.2	31.5	1,007.6	6	16	22	32	46	56.0	17.9
20	26	56	67.7	39.9	1,276.1	4	14	18	28	54	58.9	18.8
22	15	56	83.5	48.9	1,565.8	5	17	22	30	48	58.6	18.7
Total or average for all trees	189	51	43.4	23.4	749.5	4	15	19	37	44	53.9	17.3

[a] 3/8-inch basis.
[b] Veneer recovery ratio = cubic feet of dry veneer recovered divided by merchantable stem volume in cubic feet.
[c] Veneer recovery factor = square feet of dry veneer recovered (3/8-in. basis) divided by merchantable stem volume in cubic feet.

veneer peeler blocks. Across-the-grain diameters of bark distortions, fading overgrown knots, distinct overgrown knots, dead knots, and live knots (branches) were recorded. The width, length, and depth of seams and cankers were also recorded, as were the depth and location of sweep and crook. The logs were then transported to a mill, where they were conditioned and peeled into 1/10- or 1/8-inch veneer on a standard 8-foot lathe. As the veneer from each block came off the lathe, it was color-coded with a water-soluble dye so it could be identified and followed through the mill.

Veneer was clipped for maximum yield and processed through jet dryers on the mill's normal schedule. Dry veneer was graded under the direct supervision of an American Plywood Association grader and then tallied by size class (full sheet, half sheet, strip, and fishtail), by grade, and by tree and block number. Full and half sheets were counted and the width of each piece of strip and fishtail was measured to the nearest inch. Strip and fishtail were graded C or D. The average length and width of dry full and half sheets of veneer were determined by measuring a subsample of sheets.

In each study, dry veneer thickness for all veneer sizes was determined from measurements taken on a subsample of sheets and applied to each piece tallied. Dry veneer cubic volume was determined for each block. Dry veneer volume on a square foot, 3/8-inch basis was determined by multiplying dry cubic volume by 32.

Veneer cores ranged from 4.9 to 5.6 inches in diameter and averaged 5.2 inches. Average core diameter was the same for all tree and block size classes in a study.

The knot and branch defects were summarized by block for the first four blocks in each tree. Each knot and branch was classified by size, which was measured across the grain. Those measuring ≤1.5 inches were classified as grade A; those measuring >1.5 inches and ≤ 2.5 inches were classified as grade B; and those measuring ≥ 2.5 inches were classified as grade C.

These knot size classes were selected to coincide with the knot size classes used in defining standard veneer grades.[4] The number of knots and branches by size class was recorded for each block. Also recorded was the number of clear faces on each block. The number, size, and location of seams, cankers, sweep, and crook were also recorded for each block.

The defect and tree veneer-yield data were used to develop and evaluate five experimental tree-grading systems. The grading systems were designed for consistency with the standard veneer grades described in U.S. Products Standard PS 1-83 for construction and industrial plywood with typical American Plywood Association grade/trademark[4] and designed to be practical and easy to implement. The five tree grade systems evaluated were:

1. Two grades based primarily on number of clear faces in first two blocks.
2. Two grades based primarily on number of clear faces in first three blocks.
3. Two grades based primarily on size and number of knots and branches in first two blocks.
4. Two grades based primarily on size and number of knots and branches in first three blocks with up to three 1.5-inch to 2.5-inch knots allowed in the third block.
5. Four grades based primarily on grading the first three blocks individually using the size and number of knots and branches in each block.

The presence and size of seams, canker, sweep, and crook were also taken into account in each system.

The 189 trees for which veneer yield data were available were graded by computer using each of the five grading systems. Yields of veneer by grade and tree grade were summarized. Linear equations for predicting yield of veneer by grade were developed for each tree grade using the following model:

$$Y = a + b\,(D^2MH) + \varepsilon$$

where:

Y = dry veneer yield (ft.^{3})
D = tree DBH (in.)
MH = tree veneer merchantable height (ft.)
ε = experimental error

The tree-grading systems were evaluated based on how the veneer by grade was distributed among trees

[4] National Bureau of Standards. 1983. U.S. Products Standard PS 1-83 for construction and industrial plywood with typical APA grade/trademark. American Plywood Association, Tacoma, Wash. p. 44.

of different grades and on the basis of their accuracy in predicting yields of grades of veneer.

Results

Changes in lathe and peeler technology have improved veneer grade yield recovery and reduced core size since the 1970s when the data analyzed were collected. However, the basic relationships between knot and branch defects and veneer grade yield are the same. The average dry untrimmed veneer volume and grade by DBH class for the sample trees are shown in Table 1. The trees processed ranged from 9.6 to 22.7 inches in DBH and averaged 15.9 inches in DBH. The average veneer recovery ratio (VRR) was 53.9 percent. As tree size increased, the proportion of veneer in grade A generally increased, the proportion in grade B remained relatively constant, the proportion in grade C decreased, and the proportion in grade D increased.

The effect of block position in the stem on untrimmed veneer volume and grade is summarized in Table 2. Over 99 percent of the grade A veneer and 96 percent of the grade B veneer was produced in the first three blocks in the stem. More than 72 percent of the veneer from blocks above the third block was grade D, and the remainder was grade C. It is also apparent that the larger diameter trees yield a high proportion of grades A and B from their first three blocks but yield more than 80 percent grade D from blocks farther up the stem.

The rules for grading trees by the five systems are presented in Tables 3 to 7. Average veneer grade yield

TABLE 2. — *Average untrimmed veneer and proportion by grade by block position in the stem of loblolly and slash pine trees combined.*

Block position in the tree	Sample blocks	Block scaling diameter	Block large end diameter	Block volume	Veneer yield		Veneer by grade A	B	A&B	C	D	Veneer recovery ratio[b]	Veneer recovery factor[c]
	(no.)	- - - - - (in.) - - - - -		- - - (ft.^{3}) - - -		(ft.^{2})[a]	- - - - - - - - - - - - - - (%) - - - - - - - - - - - - - -						(ft.^{2}/ft.^{3})
1	189	13.2	16.4	10.1	5.9	190.7	8	28	36	52	12	58.4	18.9
2	189	12.6	13.2	8.3	5.3	168.2	7	22	29	48	23	63.3	20.3
3	179	12.3	13.0	7.8	4.6	147.1	3	12	15	39	46	58.9	18.8
4	169	11.8	12.5	7.2	4.0	128.0	0	3	3	26	72	55.5	17.8
5	155	11.1	12.0	6.5	3.2	101.0	0	1	1	16	83	48.6	15.5
6	127	10.4	11.4	5.7	2.5	79.2	0	0	0	11	89	43.4	13.9
7	77	9.6	10.9	5.0	1.8	58.8	0	0	0	12	88	36.0	11.8
8	14	8.9	10.4	4.4	1.8	58.0	0	0	0	26	74	40.9	13.2
Total or average for all trees	1,099	11.8	13.0	7.5	4.2	133.8	4	15	19	37	44	56.0	17.8

[a] 3/8-inch basis.
[b] Veneer recovery ratio = cubic feet of dry veneer recovered divided by merchantable stem volume in cubic feet.
[c] Veneer recovery factor = square feet of dry veneer recovered (3/8-in. basis) divided by merchantable stem volume in cubic feet.

TABLE 3. — *Tree grade based on number of clear faces in first two blocks in tree.*

Defect characteristics	Tree grade 1	2	Block cull
Number of clear faces in first 2 blocks	3 or 4	0, 1, or 2	
Crook and sweep in first 2 blocks	None	<3 in. per block	≥3 in., reduce merchantable height by 1 block
Seams and cankers in first 2 blocks	None	1, ≤3 in. wide, per block	>1, or >3 in. wide, reduce merchantable height by 1 block

TABLE 4. — *Tree grade based on number of clear faces in first three blocks in tree.*

Defect characteristics	Tree grade 1	2	Block cull
Number of clear faces in first 3 blocks	3 or 4	0, 1, or 2	
Crook and sweep in first 3 blocks	None	<3 in. per block	≥3 in., reduce merchantable height by 1 block
Seams and cankers in first 3 blocks	None	1, ≤3 in. wide, per block	>1, or >3 in. wide, reduce merchantable height by 1 block

TABLE 5. — *Tree grade based on size and number of knots and branches in first two blocks.*

Defect characteristics	Tree grade 1	2	Block cull
Knots ≤1.5 in. across grain in first 2 blocks	No limit	No limit	
Knots >1.5 in. and ≤2.5 in. across grain in first 2 blocks	None	No limit	
Knots >2.5 in. across grain in first 2 blocks	None	≤3 knots per ft. of stem length	>3 knots per ft. of stem, merchantability stops
Live or dead branches ≤2.5 in. across grain in first 2 blocks	None	No limit	
Live or dead branches >2.5 in. across grain in first 2 blocks	None	≤3 branches per ft. of stem length	>3 branches per ft. of stem, merchantability stops
Crook and sweep in first 2 blocks	None	<3 in. per block	≥3 in., reduce merchantable height by 1 block
Seams and cankers in first 2 blocks	None	1, ≤3 in. wide, per block	>1 per block, or >3 in. wide, reduce merchantable height by 1 block

TABLE 6. — *Tree grade based on size and number of knots and branches in first three blocks in the tree.*

Defect characteristics	Tree grade 1	2	Block cull
Knots ≤1.5 in. across grain in first 3 blocks	No limit	No limit	
Knots >1.5 in. and ≤2.5 in. across grain in first 2 blocks	None	No limit	
Knots >1.5 in. and ≤2.5 in. across grain in 3rd block	≤3 knots	No limit	
Knots >2.5 in. across grain in first 3 blocks	None	≤3 knots per ft. of stem length	>3 knots per ft. of stem, merchantability stops
Live or dead branches <2.5 in. across grain in first 3 blocks	None	No limit	
Live or dead branches >2.5 in. across grain in first 3 blocks	None	≤3 branches per ft. of stem length	>3 branches per ft. of stem, merchantability stops
Crook and sweep in first 3 blocks	None	<3 in. per block	≥3 in., reduce merchantable height by 1 block
Seams and cankers in first 3 blocks	None	1, ≤3 in. wide, per block	>1, or >3 in. wide, reduce merchantable height by 1 block

TABLE 7. — *Grade first three blocks in the tree individually for the size and number of knots and branches.*

Defect characteristics	Tree grade 1	2	3	4	Block cull
Knots ≤1.5 in. across grain	No limit	No limit	No limit	No limit	
Knots >1.5 in. and ≤2.5 in. across grain	None in first 3 blocks	None in first 2 blocks	None in first block	No limit	
Knots >2.5 in. across grain	None in first 3 blocks	None in first 2 blocks	None in first block	≤3 knots per ft. of stem length	>3 knots per ft. of stem, merchantability stops
Live or dead branches ≤2.5 in. across grain	None in first 3 blocks	None in first 2 blocks	None in first block	No limit	
Live or dead branches >2.5 in. across grain	None in first 3 blocks	None in first 2 blocks	None in first block	≤3 knots per ft. of stem length	>3 branches per ft. of stem, merchantability stops
Crook and sweep	None in first 3 blocks	None in first 2 blocks	None in first block	<3 in. per block	≥3 in. in block, reduce merchantable height by 1 block
Seams and cankers	None in first 3 blocks	None in first 2 blocks	None in first block	1, ≤3 in. wide per block	>1, or >3 in. wide, reduce merchantable height by 1 block

and proportion of grade-yield variability accounted for by grading and not grading southern pine trees are shown in Table 8. When trees were not graded, DBH and merchantable height accounted for only 16 percent of the variability in grade A veneer, 41 percent of the variability in B veneer, 62 percent of the variability in C veneer, and 73 percent of the variability in D veneer.

Grading the trees into two classes based on the number of clear faces in the first two blocks did not improve the accuracy of predictions of grade A veneer but did increase the coefficient of determination (r^2) for grade B veneer by 16 percent. When the first three blocks of grade 1 trees were graded based on number of clear faces, coefficients of determination for grades A and B veneer were 12 and 16 percent higher than they were when blocks were not graded. This grade separation resulted in the grade 1 trees yielding 31 percent grade B and better veneer compared to 17 percent for the grade 2 trees. Under this grading system, however, only 11 of the 189 trees were grade 1, because knots of any size and bark distortions were considered defects in determining clear faces.

For all veneer grades, r^2 values were higher when grade 1 trees were graded based on size and number of knots and branches in the first two blocks than they were when trees were not graded (Table 8). Grading trees based on the first three blocks increased the r^2 for each veneer grade compared to grading only the first two blocks. Grading the first three blocks based on size and number of knots and branches increased the r^2 for grade A veneer by 22 percent, B veneer by 31 percent, B and better veneer by 27 percent, C veneer by 10 percent, and D veneer by 11 percent over not grading. This grading system permitted trees to have up to three knots between 1.5 and 2.5 inches across in the third block and still make grade 1.

The last of the systems evaluated was one that assigned one of four grades to trees by grading the first three blocks individually based on size and number of knots and branches in each block. This system resulted in grade 1 trees yielding a high proportion of A and B veneer and accounted for 39 percent of the variation in grade A and 72 percent of the variation in grade B veneer (Table 8). The proportion of B and better veneer was significantly higher and the proportion of D veneer significantly lower for grade 1 trees than for grade 4 trees, while the proportion in C veneer remained relatively constant across tree grades.

Discussion

Grading the first three blocks in the stem, as opposed to the first two blocks, increased the predictability of A and B veneer for the grading systems based on number and size of knots and branches. Grading three blocks also increased the proportion of grade 1 tree veneer yield in grade B and better grades, but it reduced the number of trees graded number 1. The significant increase in r^2 for A and B veneer justifies the increased time required to grade three rather than two blocks

TABLE 8. — *Average veneer grade yield and proportion of grade yield variability accounted for with linear equations based on not grading and grading pine trees using the five tree-grading systems evaluated.*

Tree grade	Trees	DBH	Merch. height	Stem volume	Total veneer volume	Veneer yield by grade: A	B	AB	C	D	Grade yield variability accounted for with linear equation[a] — Veneer grade: A	B	AB	C	D
	(no.)	(in.)	(ft.)	---- ($ft.^3$) ----		------------- (%) -------------					------------- (r^2) -------------				
No grading system															
None	189	15.9	51	43.4	23.4	4	15	19	37	44	.16	.41	.42	.62	.73
Number of clear faces in first two blocks															
1	57	17.0	56	52.2	29.4	5	20	25	36	39	.14	.57	.53	.56	.78
2	132	15.4	48	39.6	20.9	4	11	15	38	47	.15	.28	.31	.61	.74
Number of clear faces in first three blocks															
1	11	18.6	59	60.7	36.4	7	24	31	35	34	.28	.57	.52	.52	.67
2	178	15.7	50	42.3	22.6	4	13	17	38	45	.13	.39	.41	.61	.75
Size and number of knots and branches in first two blocks															
1	65	15.8	52	44.5	24.5	5	20	25	38	37	.20	.63	.58	.68	.79
2	124	15.9	50	42.8	22.9	4	11	15	36	48	.13	.30	.34	.57	.74
Size and number of knots and branches in first three blocks with ≤3 2.5-inch knots in 3rd block															
1	55	14.5	48	35.5	18.9	6	20	26	42	31	.38	.72	.69	.72	.84
2	134	16.4	52	46.6	25.3	4	13	17	36	48	.11	.36	.39	.58	.73
Grade first three blocks individually for size and number of knots and branches															
1	33	14.9	58	37.5	20.6	6	22	28	42	30	.39	.72	.68	.71	.83
2	33	16.6	56	50.5	27.8	5	18	23	36	42	.09	.60	.57	.68	.80
3	82	15.9	49	42.1	22.6	5	13	18	36	46	.14	.34	.39	.61	.76
4	41	16.2	53	45.0	23.9	3	9	12	36	52	.21	.27	.32	.49	.71

[a] r^2 = coefficient of determination.

when the third block can be seen through the lower forest canopy (Table 8).

The effect of not counting bark distortion as a defect in determining clear faces was also examined. It appears that bark distortions are good indicators of veneer grade. When bark distortions were counted as defects, the correlation coefficient (r) for number of clear faces in the first three blocks and yield of A veneer was 0.21. But when bark distortions were not counted as defects, number of clear faces in the first three blocks had a correlation coefficient of only 0.11.

Existing tree lumber grades[1] could be used to estimate veneer grade yields, but tree lumber grades do not do as good a job as the tree-grading systems designed for veneer. The existing tree lumber grades are based on number of clear faces. These grades work well for lumber but not as well for veneer because lumber is sawn off the log on quarter faces, while veneer is peeled from around the log.

Grading trees based on size and number of knots in the first three blocks appears to be a good method for veneer. Such grading is consistent with existing grade rules for veneer, which are based on number and size of knots and knotholes. Grading trees for veneer based on size and number of knots and branches in the first three blocks combined, and allowing up to three knots between 1.5 and 2.5 inches in diameter only in the third block separates trees into two grades—grade 1 trees yielding a high proportion of A and B veneer.

To use this tree-grading system, the timber marker examines the standing tree's first three blocks for live and dead branches. If no live or dead branches are present, the tree is a potential grade 1 tree, otherwise it is a grade 2 tree. The grader then examines the potential grade 1 tree for sweep, crook, seams, and cankers in the first three blocks. If none are present, the tree is still a potential grade 1 tree. Next the timber marker examines the first two blocks of the potential grade 1 tree for knots >1.5 inches across the grain. If none are present, the tree remains grade 1. The timber marker then examines the third block of the potential grade 1 tree for knots >1.5 inches and ≤ 2.5 inches across the grain. If three or fewer are present the tree remains grade 1. Any tree having a knot >2.5 inches across the grain in the first three blocks is grade 2. If the sweep or crook in a block is excessive (≥ 3 in.), or a block contains a seam or canker >3 inches wide, or more than 1 seam or canker, the merchantable height of the grade 2 tree is reduced one block. Since the marker does not closely examine trees with branches in the first three blocks, the marker does not examine a tree closely unless the tree has a high potential to make a high-value grade 1 tree.

Trees are graded most accurately when their first three blocks are graded individually and when one of four grades is assigned to each tree.

The timber marker examines the first block in the tree for live or dead branches, knots >1.5 inches, sweep, crook, or seams. If none are present, the tree is at least a grade 3. If any of the above are present, the tree is grade 4. The grader then examines the second block of a grade 3 tree for live or dead branches, knots >1.5 inches, sweep, crook, or seams. If none are present the tree is grade 2. The third block of a grade 2 tree is then examined for live or dead branches, knots >1.5 inches, sweep, crook, or seams. If none are present the tree is grade 1.

Conclusions

Grading southern pine trees for veneer will help mill operators procure trees that yield a high proportion of grade A and B veneer. Grading the first three blocks in the stem instead of just the first two increases the selection of trees producing a high proportion of grade A and B veneer. Tree grades based on the size and number of knots and branches correlate better with veneer grade yields than do tree grades based on number of clear faces. The best grading system evaluated separated trees into four grades based on size and number of knots and branches in each of the first three blocks in the stem. When grade 1 trees were identified by this method, coefficients of determination for yields of grade A and B veneer were 23 and 31 percent higher, respectively, than when trees were not graded. Grading trees based on knot and branch size in the first three blocks combined is a good system for separating trees into two grades. The tree veneer grading systems proposed need to be field tested before they are used on a production basis.